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GRASSHOPPER SPRAY SURVEY

SASKATCHEWAN AND ALBERTA, 1986

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ABSTRACT

During the summer of 1986 the Water Quality Branch in cooperation with Alberta Environment and Saskatchewan Environment undertook a survey to assess the presence and impact of grasshopper pesticides in fluvial aquatic ecosystems in southern Saskatchewan and Alberta. Collection and field extraction of 40 litre water samples was undertaken at twelve sites in areas of Saskatchewan and Alberta known to have severe grasshopper infestions. The extracts were analyzed for five insecticides and two breakdown products. Macroinvertebrates were sampled at six stream sites in Saskatchewan to examine possible impact of insecticides on these communities. Carbofuran and chlorpyrifos were found in low concentrations in the majority of samples. The concentrations found were all well below levels reported to be toxic to aquatic organisms. No change could be detected in the macroinvertebrate communities through the period of active spraying, suggesting there were no acute toxic effects from insecticides on the macroinvertebrate populations.

Résumé

Au cours de l'été 1986, la Direction de la qualité des eaux a effectué, en collaboration avec les ministères de l'Environnement de l'Alberta et de la Saskatchewan, une étude afin de déceler la présence d'insecticides utilisés contre les sauterelles dans les écosystèmes aquatiques fluviaux du sud de la Saskatchewan et de l'Alberta et d'en déterminer les répercussions. On a recueilli et extrait des échantillons d'eau de 40 litres à douze endroits de la Saskatchewan et de l'Alberta où il y a de graves infestations de sauterelles. Dans l'analyse des échantillons, on cherchait des traces de cinq insecticides différents et de deux produits de dégradation. Des échantillons de macro-invertébrés ont également été prélevés dans six cours d'eau en Saskatchewan en vue d'examiner les répercussions possibles des insecticides sur ces populations. De faibles concentrations de carbofuran et de chlorpyrifos ont été décelées dans la plupart des échantillons, mais elles étaient toutes en deça des niveaux déclarés toxiques pour les organismes aquatiques. Au cours de la période active de pulvérisation, on n'a constaté aucun changement chez les groupes de macro-invertébrés, ce ne qui permet pas de croire que ces populations subissaient déjà de graves effets toxiques résultant de la présence d'insecticides.

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1.0 INTRODUCTION

Grasshopper infestations have been severe in the past few years in southern Saskatchewan and Alberta. As a result of these infestations, extensive chemical control has been undertaken in agricultural areas in an effort to reduce crop damage. This widespread use of pesticides for grasshopper control has raised concern among water resource managers and the public about the potential for these chemicals to enter the surface waters and the possible adverse effects this might have on aquatic organisms and domestic drinking water supplies. During the summer of 1985, Saskatchewan Environment, in cooperation with the Water Quality Branch, Environment Canada undertook a survey to examine the presence of grasshopper control pesticides in surface waters. That survey found detectable concentrations of dimethoate at two locations on the Wood River (Ferris, 1985). The samples collected in 1985 were non-preserved one litre samples which were sent to the lab for subsequent extraction and analyses.

In 1986, the forcast was for yet another year of severe grasshopper infestation. As a result, the Water Quality Branch, in cooperation with the Saskatchewan and Alberta Departments of Environment, undertook a second survey for grasshopper pesticides in surface waters. This survey examined surface waters from the same Saskatchewan sites as in the 1985 study plus a number of sites in the irrigated area of southern

Alberta. Large volume water samples were field extracted using a continuous-flow extractor developed by Goulden and Anthony, (1985). This was done in order to lower the analytical detection levels and reduce possible loss of the target compounds during pre-analysis storage.

The insecticides commonly used for grasshopper control generally have very low persistence in alkaline water, disappearing from within hours to a few days of entering the water. This factor requires that monitoring programs be conducted during periods of spraying or as soon as possible after in order to quantify environmental residues and the maximum levels of exposure to aquatic communities. The impact of pesticides on biological communities can be of much longer duration and have been considered through an examination of macroinvertebrate communties.

The timing of this survey proved to be well suited as the 1986 grasshopper infestation was extensive. In Saskatchewan, 18 million hectares were classified as areas with moderate to very severe infestation and grasshoppers caused an estimated 30 to 40 million dollars in crop loss (personal communication, L. Harris, Saskatchewan Agriculture). The severity of the infestation resulted in significant amounts of pesticides being applied in the agricultural areas.

2.0 METHODS

2.1 Water

Table 1 presents a brief description of the sampling locations and dates of sampling. A total of 12 sites were sampled, seven in Saskatchewan and five in Alberta. All the sites were flowing streams or channels except one, a slough site.

In Saskatchewan, 40 litre water samples were collected from six sites on two occasions, in late June and early July. Sample collection from the streams in June coincided with the period of intense use of pesticides. The July collection followed a period of rain which occurred across much of southern Saskatchewan from June 25 to July 1. During this period, precipitation ranged from 13.6 mm in Regina to 20.8 mm in Swift Current and 30.5 mm in Aneroid, Saskatchewan (Atmospheric Environment, 1986). One sample was collected from a slough north of Regina which is in the study area being extensively examined by Environmental Protection, Environment Canada. The slough was sampled on July 8 shortly after spraying was completed in this area (D. Waite, Environmental Protection, personal communication).

In Alberta, samples were collected in mid July at four sites in the irrigation system near Raymond and from the South Saskatchewan River near the Alberta-Saskatchewan boundary. The four sites near Raymond coincided with sites being intensively

Table 1. List of Sampling Sites and Date of Sample Collection.

Sample No.	Sampling Location	Date Sampled
1	Swift Current Creek near Simmie, Sask.	June 19, 1986
2	Swift Current Creek near Simmie, Sask.	July 3, 1986
3	Notukeu Creek at Hwy 43 near Vanguard, Sask.	June 19, 1986
4	Notukeu Creek at Hwy 43 near Vanguard, Sask.	July 4, 1986
5	Notukeu Creek at Hwy 19 south of Hodgeville, Sask.	June 19, 1986
6	Notukeu Creek at Hwy 19 south of Hodgeville, Sask.	July 4, 1986
7	Wood River near Courval, Sask.	June 19, 1986
8	Wood River near Courval, Sask.	July 4, 1986
9	Wood River at Hwy 43 near Gravelbourg, Sask.	June 19, 1986
10	Wood River at Hwy 43 near Gravelbourg, Sask.	July 3, 1986
11	Wascana Creek near Richardson, Sask.	June 23, 1986
12	Wascana Creek near Richardson, Sask.	July 7, 1986
13	Environmental Protection Slough Study North of Regina, Sask.	July 8,1986
14	Kipp Lake Creek 5 km East of Raymond, Alta.	July 15, 1986
15	Drainage Channel 5 km Northeast of Raymond, Alta.	July 15, 1986
16	Irrigation Ditch 2 km West of Junction of Hwy 4 and 506, near McNab, Alta.	July 16, 1986
17	Drainage Channel near Junction of Hwy 36 and 61, South of Taber, Alta.	July 16, 1986
18	South Saskatchewan River at Hwy 41, Northeast of Medicine Hat, Alta.	July 17, 1986

monitored for grasshopper spray chemicals by Alberta Environment. Alberta Environment collected one litre water samples at the same time as the 40 litre samples were taken by the Water Quality Branch.

2.1.1 Field Extraction

Water samples were collected in four litre glass bottles which had been solvent washed using acetone and hexane and baked prior to use. The water was extracted in the field using dichloromethane (DCM) in the continuous-flow extractor developed at the National Water Research Institute (Goulden and Anthony, 1985). Samples were collected, eight litres at a time, over approximately 90 minutes and extracted within 30 minutes of collection at a rate of 400 mL per minute. The initial DCM volume of 150 mL was supplemented by a DCM drip throughout the extraction process to compensate for the approximately 3 percent solubility of DCM. After completion of the extraction the DCM was allowed to separate and was drawn off. The extracts were refigerated in 500 mL amber glass bottles, which had been solvent washed and baked prior to use. Analyses were conducted at the Enviro-Test Laboratories in Edmonton.

Delta-BHC and perthane spikes were added to the initial 150 mL of DCM before starting the extraction. Each four litre bottle of sample water was spiked with endrin and the first bottle of water spiked with beta-BHC. Spikes were in the order of 0.1 ug. Three DCM blanks, one from each field period and two

organic-free water extracts were submitted for analysis.

2.1.2 Analytical Method

The extracts were poured into separatory funnels. The excess water was separated from the DCM and the DCM dried by passing it through an anhydrous sodium sulphate column. The DCM extracts were reduced to 2 mL using a rotary evaporator and nitrogen blow down.

The extracts were initially screened for the spiked compounds and the target pesticides using GC/MS-SIM techniques. The 2 mL of concentrated extract was further reduced to 500 uL to enhance sensitivity for both the spike compounds and the target pesticides and the samples were re-injected.

Several narrow time windows with selected ions to accommodate the compounds within the time windows were used to enhance sensitivity. The surrogates were also run separately from the target compounds to enhance sensitivity. Several duplicate injections were made to determine precision.

The analyses were conducted on a Hewlett Packard 5970 B Mass Selective Dectector equipped with a 7673A autosampler and tray.

2.2 Macroinvertebrates

Macroinvertbrate samples were collected at the six stream sites in Saskatchewan in late May, prior to spraying activities.

and at the time of water sample collection. Qualitative samples were collected using a handnet in the various habitat types present at each site in order to assess the presence of a wide variety of species. Quantitative samples were taken in triplicate at each site using either an Ekman dredge or a Surber sampler. These samples were to be used to assess the extent of change in the macroinvertebrate populations in the event that the qualitative samples showed substantial change between sampling dates.

Samples were preserved in formalin and returned to the laboratory, where they were hand sorted from any debris and transfered to alcohol. Indentification was done using keys by Pennak (1978), Edmondson (1959) and Usinger (1956).

3.0 RESULTS

3.1 Water

The results of the chemical analyses of water extracts are presented in Table 2. Carbofuran and chlorpyrifos were found in the majority of samples. Dimethoate and malathion were each found only once, in different samples from the irrigation system in Alberta. Carbaryl was present in two samples, one from Notukeu Creek and one from the irrigation system in Alberta.

The highest carbofuran concentrations were found in samples from the slough north of Regina, the irrigation system in Alberta and the June sample from Notukeu Creek at Highway 43.

Table 2. Analytical Results of Large Volume Water Sample Extracts (ug/L).

Sample No.	Date Sampled	Dimetho-ate	Dimetho-xon	Carbaryl	Carbo-furan	3-OH Car-bofuran	Mala-thion	Chlor-pyrifos
1	19/6	N.D	N.D.	N.D.	0.0033	N.D.	N.D.	N.D.
2	3/7	N.D	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
3	19/6	N.D	N.D.	0.022	0.029	N.D.	N.D.	0.015
4	4/7	N.D	N.D.	N.D.	N.D.	N.D.	N.D.	0.0035
5A	19/6	N.D	N.D.	N.D.	0.0050	N.D.	N.D.	0.0015
5B	19/6	N.D	N.D.	N.D.	0.0048	N.D.	N.D.	0.0015
6	4/7	N.D	N.D.	N.D.	0.0030	N.D.	N.D.	0.0013
7 *	19/6	N.D	N.D.	N.D.	0.0045	N.D.	N.D.	N.D.
8	4/7	N.D	N.D.	N.D.	0.0015	N.D.	N.D.	0.0005
9	19/6	N.D	N.D.	N.D.	0.0028	N.D.	N.D.	0.0013
10	3/7	N.D	N.D.	N.D.	0.0025	N.D.	N.D.	0.0008
11A	23/6	N.D	N.D.	N.D.	N.D.	N.D.	N.D.	0.0048
11B	23/6	N.D	N.D.	N.D.	N.D.	N.D.	N.D.	0.0045
12	7/7	N.D	N.D.	N.D.	N.D.	N.D.	N.D.	0.0063
13	8/7	N.D	N.D.	N.D.	0.072	N.D.	N.D.	0.0013
14	15/7	N.D	N.D.	N.D.	0.027	N.D.	N.D.	0.0038
15	15/7	N.D	N.D.	N.D.	0.0085	N.D.	0.0033	0.0023
16	16/7	0.0048	N.D.	N.D.	0.0015	N.D.	N.D.	0.0025
17	16/7	N.D	N.D.	0.0059	0.052	N.D.	N.D.	0.0030
18A	17/7	N.D	N.D.	N.D.	0.0018	N.D.	N.D.	N.D.
18B	17/7	N.D	N.D.	N.D.	0.0018	N.D.	N.D.	N.D.
D.L.		0.0005	0.0013	0.0005	0.0005	0.0013	0.0005	0.0005

note - D.L. denotes detection level
- N.D. denotes non-detection
- * detection levels for this sample are twice as high as those shown as only 20 L of water were extracted
- A and B sample number represent repeat analysis of same sample

The Notukeu Creek sample also had the highest chlorpyrifos and carbaryl concentration found in the survey. Comparison of the June and July results for the Saskatchewan streams shows that carbofuran concentrations were consistantly higher in June. The chlorpyrifos results do not display a similar pattern of consistantly higher results during either of the sampling periods.

Analyses for carbofuran and dimethoate breakdown products, 3-OH-carbofuran and dimethoxon, were all below detection. A summary of the results of water and DCM spikes are presented in Table 3. These results show higher than expected recoveries for the spike compounds. This suggests that the quantification of results for the target chemicals may be overestimated.

Table 3. Summary of Analytical Recoveries for Spiked Compounds.

Compound	Mean Recovery	Range of Recovery Low	High
Delta-BHC	150 %	60 %	250 %
Beta-BHC	180 %	90 %	220 %
Endrin	170 %	70 %	350 %
Perthane	110 %	60 %	210 %

Quality assurance samples of the DCM used for the extractions and organic-free water used in wash up all had non-detectable levels of the compounds analyzed.

3.2 Macroinvertebrates

The species lists for the handnet collections of macroinvertebrates are presented in Appendix A. These species lists show no significant change in the species of macroinvertebrates present between collection dates. As a major change in the macroinvertebrate population would be necessary before it could be detected by the quantitative samples, it was felt that analysis of the quantitative macroinvertebrate samples was not warranted. The lack of significant change in the species present at each site, shows that no significant acutely toxic impact occurred in the macroinvertebrate populations, which could be attributed to pesticides in the water.

4.0 DISCUSSION

Of the chemicals analyzed, carbofuran and carbaryl were extensively used for grasshopper control. Carbofuran was the chemical of choice for most farmers in Saskatchewan (L. Harris, Sask. Agriculture, personal communication). This choice was for the most part based on price and availability. The widespread use of carbofuran is reflected in the results of the survey, most samples having measurable concentrations of carbofuran.

Detailed chemical use information is not available for the various river basins sampled. Detailed use data were gathered by Environmental Protection for the slough study area north of

Regina. In that catch basin carbaryl, carbofuran, dimethoate, and deltamethrin were used (289.8, 87.7, 4.8, and 3.9 kg active ingredient, respectively) during 1986 (D. Waite, personal communication). Environmental Protection did not find detectable levels of these compounds in their water sampling program but did find detectable levels of carbofuran in precipitation samples (combined wet and dry precipitation) collected July 2 and 8, and of carbaryl on June 24. July 8 coincided with our sampling of the slough which had the highest level of carbofuran (0.072 ug/L) found in our survey.

Alberta Environment collected one litre water samples daily from the four sites in the irrigation system near Raymond, Alberta, over a thirty day period. These samples were analyzed for carbofuran, carbaryl and chlorpyrifos. Samples from the latter half of their study were also analyzed for dimethoate. Carbofuran and dimethoate were detected periodically above the detection level of 0.5 ug/L. Carbaryl and chlorpyrifos were not detected. Of the four samples collected which coincided with the samples collected in our survey, one had a carbofuran concentration of 2.0 ug/L. The other samples and chemicals were all below the detection level of 0.5 ug/L (R. Chisholm, Alberta Environment, personal communication). The positive detection of carbofuran was in a sample from Kipp Lake Creek and corresponds to our sample number 14, which had a concentration of 0.029 ug/L. The reason for the large difference in the two results is unclear, however differences in collection and extraction

methods may have contributed. Both samples were analyzed at Enviro-Test Laboratories.

The high recovery results for the spikes indicates that the concentrations presented in Table 3 may be overestimations. The presence and relative abundance of the compounds detected, however, show the existence of the various compounds in the surface water and the relative differences in the concentration between samples. The higher concentrations of carbofuran in the June samples relative to the July samples suggest that contamination during the period of active spraying was greater than following a rain event after spraying was completed. This probably reflects the rapid degradation of carbofuran in alkaline water. Chapman and Cole (1982) reported 50 percent degradation of carbofuran in one week in water with a pH of 8.0.

The similarity of the macroinvertebrate communities during the study period indicate there was no major effect on the macroinvertbrates from the pesticide contamination. Toxicity data in the literature show that the low concentrations of the five insecticides found in this survey are all significantly lower than the toxic levels for aquatic organisms. Toxic levels of carbofuran for fish, the most sensitive aquatic organism, range from 80 to 1420 ug/L (Eisler, 1985; National Research Council Canada, 1979). Toxicity data for chlorpyrifos show toxic effects at concentrations as low as 0.1 ug/L for invertebrates (Gammarus lacustris) and 0.58 ug/L for striped bass (National Research Council Canada, 1978). The toxicity of

the other three insecticides to aquatic organisms are in the mg/L range (Worthing and Walker, 1983).

5.0 CONCLUSIONS

Carbofuran and chlorpyrifos were found at detectable levels in the majority of water samples. Dimethoate, carbaryl and malathion were found in only a few samples. The concentrations of the five insecticides were generally low. All concentrations were much lower than the toxic levels reported in the literature for aquatic organisms. The higher concentrations of carbofuran found in the June samples suggest that greater quantities of carbofuran were present in the water bodies examined during periods of active spraying than after a precipitation event following the period of active spraying.

Examination of macroinvertebrate populations showed no significant change in the species present at the six stream sites in Saskatchewan over the spraying period.

The low concentrations of pesticides found in the water and the lack of noticable impact on macroinvertebrates suggest the these compounds had little adverse effect on the aquatic systems examined. However, concentrations may have been higher at other times during the spray season as these compounds generally have very low persistance in alkaline water or adverse effects may have occurred in other aquatic organisms which would not be detected by the sampling program undertaken in this survey.

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APPENDIX A

MACROINVERTEBRATE SPECIES LISTS

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Table 1. Macroinvertebrate Species List for Wascana Creek near Richardson, Saskatchewan.

Species	Collection Date		
	6/6/86	23/6/86	7/7/86
Annelida			
Hirudinea	3		2
Eubranchiopoda			
Conchostraca	X		
Amphipoda			
Tatitridae			
Hyalella azteca	X		
Gammaridae			
Gammarus sp.	X		
Insecta			
Ephemeroptera			
Siphlonuridae			
Siphlonurus sp.		X	
Caenidae			
Caenis sp.	X		
Odonata			
Coenagriidae			
Enallagma sp.	X	X	X
Aeshnidae			
Anax sp.	X		
Hemiptera			
Corixidae (early instar)	2	2	2
Trichorixa sp.	X	X	X
Gerridae			
Gerris sp.	X		X
Notonectidae		X	
Coleoptera			
Dytiscidae (larva)	X		X
Dytiscidae			
Ilybius sp.	X		X
Noteridae			
Pronoterus sp.	X	X	X
Haliplidae			
Haliplus sp.	X	X	
Gyrinidae			
Gyretes sp.	X		
Curculionidae			
Hyperodes sp.	X		

Table 1. Macroinvertebrate Species List for Wascana Creek near Richardson, Saskatchewan (Continued).

Species	Collection Date		
	6/6/86	23/6/86	7/7/86
Trichoptera			
Limnephilidae			
Hesperophylax sp.	X	X	
Pycnapsyche sp.	X	X	X
Leptoceridae			
Triaenodes sp.		X	
Diptera			
Chironomidae	X	X	X
Arachnida			
Acarina	X	X	X
Mollusca			
Gastropda			
Physidae			
Physa sp.	X	X	X
Lymnaidae			
Lymnaea sp.	X	X	X
Planorbidae			
Helisoma sp.	X	X	
Gyraulus sp.	X	X	X
Pelecypoda			
Sphariidae	X		

Note - numbers indicate the number of different unclassified species in group

Table 2. Macroinvertebrate Species List for Swift Current Creek near Simmie, Saskatchewan.

Species	Collection Date		
	28/5/86	19/6/86	3/7/86
Annelida			
Hirudinea	X		
Amphipoda			
Tatitridae			
Hyalella azteca	X	X	X
Gammaridae			
Gammarus sp.	X	X	X
Insecta			
Ephemeroptera			
Siphlonuridae			
Siphlonurus sp.	X	X	
Caenidae			
Caenis sp.	X		X
Odonata			
Coenagriidae			
Enallagma sp.	X	X	
Hemiptera			
Corixidae			
Trichorixa sp.	X	X	X
Gerridae			
Gerris sp.		X	
Gelastocoridae (nymph)			X
Coleoptera			
Dytiscidae (larva)	X	X	X
Deronectes sp.		X	X
Hydrophildae (larva)	X		
Haliplidae			
Haliplus sp.	X	X	X
Gyrinidae (larva)			X
Gyrinidae			
Gyretes sp.		X	
Trichoptera			
Helicopsychidae			
Helicopsyche sp.	X		X
Limnephilidae			
Hesperophylax sp.	X	X	X
Rhyacopotamidae			
Chimarra sp.	X	X	X

Table 2. Macroinvertebrate Species List for Swift Current Creek near Simmie, Saskatchewan (Continued).

Species	Collection Date		
	28/5/86	19/6/86	3/7/86
Diptera			
Chironomidae	X	X	X
Simulidae	X	X	X
Arachnida			
Acarina			X
Mollusca			
Gastropda			
Physidae			
Physa sp.		X	X
Lymnaidae			
Lymnaea sp.	X	X	X

Table 3. Macroinvertebrate Species List for Wood River at Highway 43, near Gravelbourg, Saskatchewan.

Species	Collection Date		
	29/5/86	18/6/86	3/7/86
Annelida			
Hirudinea	X		X
Amphipoda			
Tatitridae			
Hyalella azteca	X	X	X
Gammaridae			
Gammarus sp.	X	X	X
Insecta			
Ephemeroptera			
Siphlonuridae			
Siphlonurus sp.		X	
Caenidae			
Caenis sp.	X	X	
Odonata			
Coenagriidae			
Enallagma sp.	X	X	X
Aeshnidae			
Anax sp.			X
Hemiptera			
Corixidae			
Trichorixa sp.	X	X	X
Coleoptera			
Dytiscidae (larva)		X	X
Dytiscidae			
Hygrotus sp.	X	X	
Laccophilus sp.		X	X
Noteridae			X
Haliplidae			
Haliplus sp.	X	X	X
Gyrinidae			
Gyretes sp.	X		
Hydrophilidae	X		X
Trichoptera			
Limnephilidae			
Hesperophylax sp.	X		
Limnephilus sp.			X

Table 3. Macroinvertebrate Species List for Wood River at Highway 43, near Gravelbourg, Saskatchewan (Continued).

Species	Collection Date		
	29/5/86	18/6/86	4/7/86
Diptera			
Chironomidae	X	X	X
Stratiomyidae			
Hedriodisus sp.		X	
Arachnida			
Acarina	X	X	X
Mollusca			
Gastropda			
Physidae			
Physa sp.	X	X	X
Lymnaidae			
Lymnaea sp.	X	X	X
Planorbidae			
Helisoma sp.	X	X	X
Pelecypoda			
Sphariidae		X	

Table 4. Macroinvertebrate Species List for Wood River near Courval, Saskatchewan.

Species	Collection Date		
	28/5/86	18/6/86	4/7/86
Annelida			
Hirudinea	2		
Eubranchiopoda			
Conchostraca	X		
Amphipoda			
Tatitridae			
Hyalella azteca	X	X	X
Gammaridae			
Gammarus sp.	X	X	
Insecta			
Odonata			
Coenagriidae	X	X	
Hemiptera			
Corixidae (early instar)	X	X	X
Trichorixa sp.	X		
Coleoptera			
Dytiscidae (larva)	X	X	X
Dytiscidae			
Hygrotus sp.	X		
Gyrinidae (larva)			
Gyretes sp.			X
Hydrophilidae			
Hydrochus sp.	X		
Trichoptera			
Limnephilidae			
Hesperophylax sp.	X	X	
Leptoceridae			
Triaenodes sp.	X		
Diptera			
Chironomidae	X	X	X

Table 4. Macroinvertebrate Species List for Wood River near Courval, Saskatchewan (Continued).

Species	Collection Date		
	28/5/86	18/6/86	4/7/86
Arachnida			
Acarina	2		2
Mollusca			
Gastropda			
Physidae			
Physa sp.	X	X	X
Lymnaidae			
Lymnaea sp.	X		X
Planorbidae			
Gyraulus sp.	X		X

Note - numbers indicate the number of different unclassified species in group

Table 5. Macroinvertebrate Species List for Notukeu Creek at Highway 43, near Vanguard, Saskatchewan.

Species	Collection Date		
	29/5/86	18/6/86	4/7/86
Annelida			
Hirudinea	2		X
Eubranchiopoda			
Conchostraca		X	
Amphipoda			
Tatitridae			
Hyalella azteca	X	X	X
Gammaridae			
Gammarus sp.	X	X	X
Insecta			
Ephemeroptera			
Caenidae			
Caenis sp.	X		
Odonata			
Coenagriidae			
Enallagma sp.	X	X	X
Lestidae			
Lestes sp.			X
Hemiptera			
Corixidae (early instar)			X
Trichorixa sp.	X	X	
Notonectidae	X	X	
Coleoptera			
Dytiscidae (larva)	X	X	X
Dytiscidae			
Ilybius sp.			X
Hygrotes sp.	X	X	
Laccophilus sp.	X	X	X
Acilius sp.		X	
Graphoderus sp.			X
Curculionidae			
Hyperodes sp.	X		
Trichoptera			
Limnephilidae			
Hesperophylax sp.	X	X	X
Diptera			
Chironomidae	X	X	

Table 5. Macroinvertebrate Species List for Notukeu Creek at Highway 43, near Vanguard, Saskatchewan (Continued).

Species	Collection Date		
	29/5/86	18/6/86	4/7/86
Arachnida			
Acarina	X		
Mollusca			
Gastropda			
Physidae			
Physa sp.	X	X	X
Lymnaidae			
Lymnaea sp.	X	X	X
Planorbidae			
Gyraulus sp.	X	X	X

Note - numbers indicate the number of different unclassified species in group

Table 6. Macroinvertebrate Species List for Notukeu Creek at Highway 19, south of Hodgeville, Saskatchewan.

Species	Collection Date		
	29/5/86	18/6/86	4/7/86
Annelida			
Hirudinea	X		X
Amphipoda			
Tatitridae			
Hyalella azteca	X		X
Gammaridae			
Gammarus sp.	X	X	X
Insecta			
Ephemeroptera			
Siphlonuridae			
Siphlonurus sp.			X
Caenidae			
Caenis sp.			X
Odonata			
Coenagriidae			
Enallagma sp.		X	X
Aeshnidae			
Anax sp.	X		X
Hemiptera			
Corixidae			
Trichorixa sp.			X
Coleoptera			
Dytiscidae			
Ilybius sp.			X
Hygrotes sp.	X	X	X
Haliplidae			
Haliplus sp.			X
Hydrophilidae			
Hydrochus sp.	X		X
Trichoptera			
Limnephilidae			
Hesperophylax sp.	X	X	X
Diptera			
Chironomidae	X		X
Simulidae	X	X	X

Table 6. Macroinvertebrate Species List for Notukeu Creek at Highway 19, South of Hodgeville, Saskatchewan (Continued).

Species	Collection Date		
	29/5/86	18/6/86	4/7/86
Arachnida			
Acarina			X
Mollusca			
Gastropda			
Physidae			
Physa sp.	X	X	X
Lymnaidae			
Lymnaea sp.	X	X	X
Planorbidae			
Gyraulus sp.	X		
Helisoma sp.		X	X
Pelecypoda			
Sphariidae	X	X	